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Maritimes Region

Canadian Science Advisory Secretariat
Science Response 2017/020

STOCK STATUS UPDATE OF ATLANTIC SALMON IN SALMON FISHING AREAS (SFAs) 19-21 AND 23

Context

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) identified four large groups of Atlantic Salmon (*Salmo salar*), referred to as Designatable Units (DUs), in the Maritimes Region: Eastern Cape Breton (ECB; corresponding to Salmon Fishing Area (SFA) 19), Nova Scotia Southern Upland (SU; SFAs 20, 21 and part of 22), Outer Bay of Fundy (OBoF; corresponding to the western part of SFA 23), and Inner Bay of Fundy (IBoF; part of SFAs 22 and 23) (see Appendix).

Abundance of Atlantic Salmon in the Maritimes Region has been in decline for more than two decades. Populations in many rivers are extirpated and IBoF salmon are listed as Endangered under the Species at Risk Act (SARA). In November 2010, COSEWIC assessed the ECB, SU and OBoF population assemblages as Endangered. Fisheries and Oceans Canada (DFO) has completed Scientific Recovery Potential Assessments, Socio-Economic Analyses, and public consultations for these DUs to inform the decision on whether or not they will be listed under SARA.

Science advice on the status of Atlantic Salmon in SFAs 19-21 and 23 for 2016 was requested by Fisheries and Aquaculture Management. This advice is used to inform Aboriginal communities, clients, and the provinces of Nova Scotia and New Brunswick of the status of the Salmon resource in advance of developing harvest agreements and recreational fishing plans for 2017. The objectives of the request were to assess the status of Atlantic Salmon stocks in SFAs 19, 20, 21 and 23 up to the end of 2016 using the following indicators:

- adult abundance relative to reference levels;
- juveniles densities; and
- smolt production estimates.

Given that this request is for an update of previous advice using established methods (DFO 2014, DFO 2015, DFO 2016, and references therein), it was decided to use the Science Response Process.

This Science Response Report results from the Science Response Process of March 8, 2017, on the Stock Status Update of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23.

Analysis and Response

Methods

Evaluation of the status of Atlantic Salmon in the Maritimes Region is based on abundance monitoring for a number of index populations. For most index populations, status is evaluated using a comparison of the estimated egg deposition (calculated from the estimated abundance and biological characteristics of Salmon stocks) relative to a reference point known as the conservation egg requirement. The river-specific conservation egg requirement is based on an

egg deposition of 2.4 eggs/m^2 multiplied by the amount of accessible fluvial rearing habitat that is of suitable gradient. An egg deposition of 2.4 eggs/m^2 is considered to be a Limit Reference Point in the context of DFO's Precautionary Approach Framework (DFO 2009, DFO 2012, Gibson and Claytor 2012) for DFO's Maritimes Region. Conservation requirements for many of the rivers in the Maritimes Region are reported in O'Connell et al. (1997).

In this report, Salmon less than 63 cm in fork length are referred to as small, and Salmon greater than or equal to 63 cm in fork length are referred to as large; one-sea-winter Salmon are those which return to spawn following a single winter at sea (also termed Grilse) and multi-sea-winter (MSW) Salmon include those fish which return following two or more winters at sea and repeat spawners. Juvenile Salmon abundance determined from electrofishing surveys is compared to Elson's norm values of 29 fry/100 m^2 and 38 parr/100 m^2 (Elson 1967). A smolt production estimate of 3.8 smolt/100 m^2 (Symons 1979) is sometimes used as a general reference value for rivers at or near the egg conservation requirement, and is provided here to allow for a comparison of smolt production estimates.

Eastern Cape Breton (SFA 19)

Salmon population monitoring by DFO in ECB is currently focused on three river systems: the Middle, Baddeck, and North rivers (Table 1). Parks Canada (PC) monitors adult Salmon abundance on Clyburn Brook (Table 1) using dive surveys similar to those conducted by DFO. The Unama'ki Institute of Natural Resources (UINR) began monitoring smolts on Middle River in 2011, and smolt population estimates are available for 2013-2016 (Table 2). Collaborative electrofishing surveys were also conducted in ECB by DFO and partners, and Parks Canada in 2016 (Table 3). Details on the assessment methods for ECB Salmon populations are provided in Levy and Gibson (2014), DFO (2013), Gibson and Bowlby (2009), and Robichaud-LeBlanc and Amiro (2004).

In 2016, all rivers within SFA 19 with the exception of the Middle, Baddeck, and North rivers were closed to Salmon fishing all year. The Middle and Baddeck rivers were open to catch-and-release angling from October 1st to October 31st and the North River (downstream from the area known as "The Benches") was open to catch-and-release angling from June 1st to July 15th and September 1st to October 31st (Table 1). In 2016, the reach of North River between "The Benches" and the Little Falls pool was closed to angling of any species from July 15th to August 31st. A Provincial stocking program exists on the Middle and Baddeck rivers, which aims to numerically offset anticipated catch and release mortalities on these rivers (DFO 2010). Food, Social and Ceremonial (FSC) allocations were available to First Nations on these three rivers in 2016; however, reports indicate that no tags were distributed and there were no harvests from these rivers.

In 2016, all index populations in ECB were assessed to be below conservation egg requirements (Table 1), with estimated values of 34, 30, and 79 percent of the requirements for the Middle, Baddeck and North rivers respectively. The Salmon abundance in Clyburn Brook also continues to remain low with 12 Salmon counted in 2016. Smolt abundance estimates for Middle River ranged from 11,103 in 2013 to 24,110 in 2015, with an estimate of 14,848 smolts in 2016 (Table 2). The corresponding smolt production estimates are below the reference value of 3.8 smolts/100 m^2 (Symons 1979). Electrofishing surveys were conducted on 15 ECB rivers in 2016 (Table 3). Estimated juvenile densities for three of the 15 rivers were at or exceeded Elson's norm values; however, the number of sites surveyed on these rivers was low (i.e., only 1-2 sites surveyed per river). A summary of the 2016 assessment results is provided in Tables 1, 2 and 3 and a time series showing the status of adult Salmon populations for the Middle and Baddeck, North, and Clyburn rivers are provided in Figures 1, 2, and 3, respectively.

Table 1. Atlantic Salmon assessment information for index rivers in SFA 19 during 2016, including catch-and-release angling seasons, conservation egg requirements, preliminary recreational catch and effort estimates, catch and release mortality estimates, dive count results, escapement estimates, percent conservation egg requirement attained, and Provincial stocking information.

	Middle River	Baddeck River	North River	Clyburn Brook
2016 Angling Season	October 1st - 31st	October 1st - 31st	June 1st - July 15th and Sept. 1st -Oct. 31st	Closed
Assessment Information	- Recreational Catch Estimates - Dive Counts - Mark Recapture Data (historical) - Electrofishing Data (historical) - Smolt Estimate	- Recreational Catch Estimates - Dive Counts - Mark Recapture Data (historical) - Electrofishing Data	- Recreational Catch Estimates - Dive Counts - Mark Recapture Data	- Dive Counts - Electrofishing Data
Conservation Egg Requirement (millions of eggs)	2.07	2.01	0.92	0.28
Preliminary Recreational Catch Estimates:*				
Small Salmon	9	13	8	Not Applicable
Large Salmon	26	26	42	Not Applicable
Effort (rod-days)	191	156	129	Not Applicable
Total Catch and Release Mortality Estimates**	1	2	2	Not Applicable
Dive Counts:***				
Small Salmon	25	16	34	3
Large Salmon	185	85	105	9
Marks / Recaptures	Not Applicable	Not Applicable	26 / 13	Not Applicable
Estimated Escapement:***				
Small Salmon	31	29	55	Not Applicable
Large Salmon	196	114	171	Not Applicable
% Conservation Egg Requirement (Bayesian 90% credible interval)	**34 (25-44)**	**30 (22-40)**	**79**	**Not Applicable**
Provincial Stocking:				
Broodstock Collections	4 large, 4 small (October)	4 large, 4 small (October)	Not Applicable	Not Applicable
Juvenile Releases	~24,000 fin clipped 0+ parr (November)	~28,300 fin clipped 0+ parr (December)	Not Applicable	Not Applicable

*Salmo-NS Database queried on Feb. 16, 2017. River specific mean scaling factors for small Salmon, large Salmon, and effort were used to estimate catch and effort in 2016 (see Sources of Uncertainty).

**An assumed 4% mortality rate is applied to estimate catch-and-release mortalities (DFO 2013).

***For North River, escapement was estimated using the Oct. 6th dive count results and the maximum observation rate for dive counts on the North River during 1994-98, 2013, and 2015 (see Sources of Uncertainty). The counts for small and large Salmon reported in Table 1 include marked and unmarked fish. For Middle River, 2 dive counts were conducted: one on Oct. 25th where 129 large and 32 small Salmon were counted; and another on Oct. 27th where 185 large and 25 small Salmon were counted. The Oct. 25th count followed a heavy rain event on Oct. 22nd, and the visibility in the lower reach of the river was considered to be unsuitable for population assessment purposes; therefore, the Oct. 27th dive count results were used for population assessment purposes. Parks Canada conducted the dive count on Clyburn Brook on November 3, 2017.

Table 2. Estimates of wild and hatchery Atlantic Salmon smolt abundance, production per unit area of habitat (smolts/100 m^2), and one-sea-winter (1SW) and two-sea-winter (2SW) return rates for Middle River.

Smolt Year (t)	Smolt Estimate*	95% Confidence Interval	Production Per Unit Area (smolts/100 m^2)	Return Rate (%)	
				1SW (t+1)	2SW** (t+2)
2013	11,103	6,848 - 15,359	1.43	0.20	1.68
2014* **	11,907	2,471 - 21,343	1.53	0.37	1.52
2015	24,110	12,057 - 36,164	3.10	0.15	NA
2016	14,848	8,451 - 21,244	1.91	NA	NA

NA = Not Applicable
*Source: Smolt estimates provided by UINR. The smolt population was estimated using a single trap mark-recapture experiment and the Adjusted Peterson Estimate (Ricker 1975). All Salmon >10.0 cm, not clearly resembling parr, were assumed to be smolts (see Sources of Uncertainty).
**Ninety percent of large Salmon were assumed to be maiden 2SW Salmon based on the aging of scale samples collected from adult Salmon on Middle River during 1995–1998, 2003, and 2004.
***The number of recaptures was low in 2014 (i.e., only 4 recaptures) resulting in greater uncertainty associated with this estimate.

Table 3. Number of sites surveyed and juvenile Salmon densities from electrofishing surveys conducted in Eastern Cape Breton rivers in 2016.

River	Electrofishing Crew*	Number of Sites	Mean Density (fish/100m^2)**	
			Age-0 Parr (Fry)	Total Age-1 and Older Parr
Baddeck River	**UINR**, DFO	2	81.3	44.2
Benacadie River	**UINR**, DFO	2	4.1	26.8
Breac Brook	**UINR**, DFO	1	24.4	19.4
Clyburn Brook	**PC**	2	5.5	20.1
Dundas Brook	**PC**	1	26.6	7.0
Framboise River	**DFO**, RCWA, UINR	4	9.9	8.6
Grand River	**DFO**, UINR, RCWA	9	8.8	4.5
Indian Brook	**UINR**, DFO	1	31.6	37.6
Neil Brook	**PC**	2	4.1	4.1
River Denys	**UINR**, DFO	2	48.2	41.1
River Inhabitants	**DFO**, UINR, RCWA	3	9.8	14.9
River Tillard	**DFO**, RCWA, UINR	3	4.1	7.7
Skye River	**UINR**, DFO	2	15.0	27.5
Sydney River	**UINR**, DFO	2	14.9	35.0
Warren Brook	**PC**	1	4.1	4.1

*Electrofishing crew consisted of staff from Fisheries and Oceans Canada (DFO), Unama'ki Institute of Natural Resources (UINR), Richmond County Wildlife Association (RCWA), and Parks Canada (PC). Lead organisation identified first and in bold.
**Juvenile Salmon densities were estimated using a relationship between CPUE and density following methods in Chaput et al. (2005) and recent site calibration data from the Margaree River from 2001, 2002, 2015, and 2016 provided courtesy of Sophie LeBlanc, Gulf Region, DFO. This assessment method provides a small juvenile density estimate (e.g., 4.1 fish / 100m^2) for sites where 0 individuals of that life stage were captured (see Sources of Uncertainty).

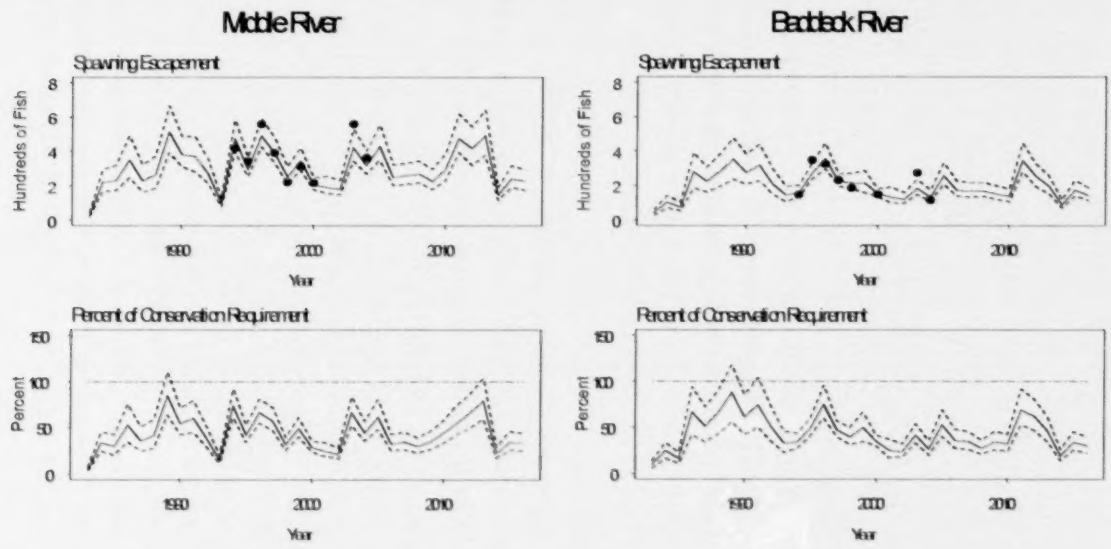

Figure 1. Estimated total number of spawners (top graph) and the percent of the conservation egg requirement attained (bottom graph) for Middle River (left panel) and Baddeck River (right panel), NS, from 1983 to 2016. Model fits derived from two methods are shown. The solid lines show the maximum likelihood estimates of annual abundance. The dashed lines show the Bayesian 90% credible interval for the annual abundance estimates. The points in the top graphs are the population estimates obtained by mark recapture during the dive surveys. The horizontal dashed line in the bottom graphs indicates 100% of the conservation egg requirement for each river.

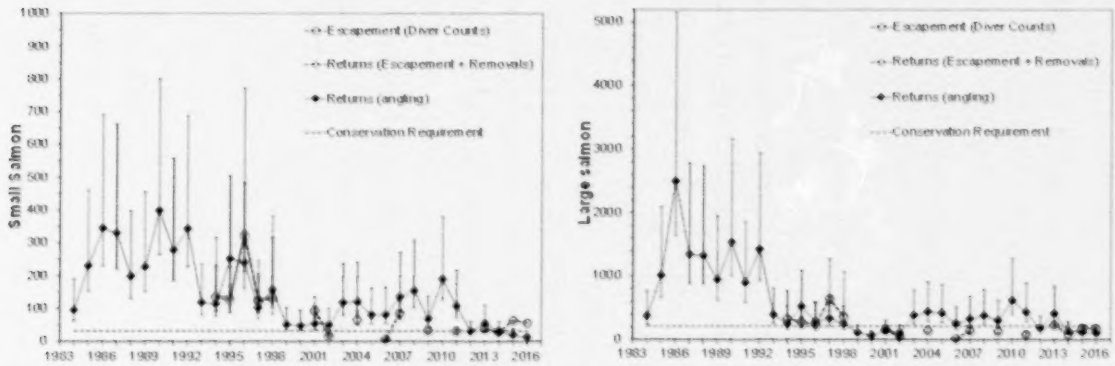

Figure 2. Estimates of the number of Salmon returning to spawn and the spawning escapement for small and large Salmon in North River, NS, as derived from dive survey counts and from recreational catch data. The expected number of small or large Salmon necessary to meet the egg conservation requirement is shown by the horizontal dashed line. Error bars represent 90% confidence intervals.

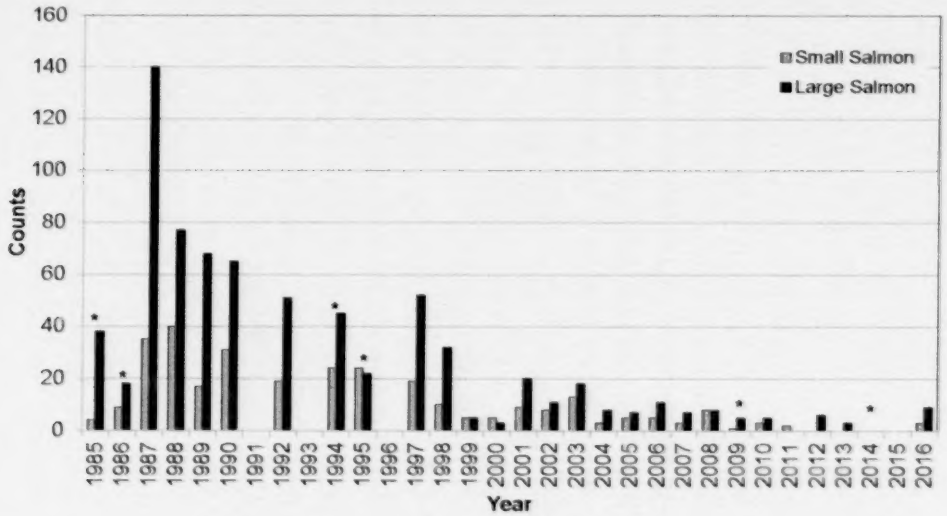

Figure 3. Counts of small and large Salmon in Clyburn Brook, NS, from 1985 to 2016. Years in which only the lower section of the river was surveyed (partial counts) are identified with an asterisk (*). No count was conducted in 1991, 1993, 1996, and 2015. Source: Parks Canada.

Southern Upland of Nova Scotia (SFAs 20, 21 and Part of SFA 22)

Atlantic Salmon assessment activities in the SU region are currently focused on two populations: the St. Mary's River, the index population for SFA 20, and the LaHave River, the index population for SFA 21. Beginning in 2010, all rivers within SFA 20 and SFA 21 were closed to recreational fishing for Atlantic Salmon and there were no FSC allocations. Details on the assessment methods for SU Salmon populations are provided in DFO (2013) and Gibson et al. (2009).

In 2016, the LaHave River Salmon population above Morgan Falls remained below the conservation egg requirement with an estimated egg deposition of 4% of the requirement. Fry and total parr (age one and older) densities (Table 4) on the St. Mary's and LaHave rivers were also low and remain well below Elson's norm values. The smolt production estimate for the LaHave River in 2016 (Table 5) was less than 1.0 smolt/100 m^2 of productive habitat, which is very low in comparison to the reference value of 3.8 smolts/100 m^2 (Symons 1979). Smolt to adult return rates (a proxy for marine survival) for 1SW Salmon on the LaHave River have declined to values less than 1% for the 2013, 2014 and 2015 smolt cohorts (Table 5, Figure 5). Smolts (n=163) were captured from the West Branch of the St. Mary's River using a Rotary Screw Trap (also referred to as a smolt wheel); however, no mark-recapture experiment was conducted to estimate smolt abundance and/or production. A summary of the 2016 assessment results is provided in Tables 4 and 5, and time series showing adult returns and estimated egg depositions in the LaHave River above Morgan Falls are provided in Figure 4, and a time series showing smolt-to-adult Salmon return rates is provided in Figure 5.

Table 4. Atlantic Salmon assessment information for index rivers in SFAs 20 and 21 during 2016, including angling seasons, conservation egg requirements, fishway count, percent conservation egg requirement attained, and juvenile assessment results.

	St. Mary's River	LaHave River (Above Morgan Falls)
2016 Angling Season	Closed	Closed
Assessment Information	- Juvenile Electrofishing Surveys	- Juvenile Electrofishing Surveys (above and below Morgan Falls) - Smolt Assessment - Fishway Count
Conservation Egg Requirement (millions of eggs)	9.56	6.22*
Fishway Count:**		
Small Salmon	NA	23
Large Salmon	NA	45
% Conservation Egg Requirement	**NA**	**4**
Number of Sites Surveyed and Electrofishing Densities (fish/100 m^2)*:**		
Number of Sites	9	5
Age-0 Parr (Fry)	10.0	10.7
Total Age-1 and Older Parr	2.4	1.7

NA = Not Applicable
*The conservation egg requirement reported by O'Connell et al. (1997) has been scaled according to the proportion of habitat area above Morgan Falls (i.e., 51%).
**Corrected for observed fallbacks.
***Water levels were extremely low on the LaHave River during the summer of 2016. As a result, electrofishing surveys were only conducted at a limited number of sites where water levels were considered to be sufficient for the activity; this included one site in the main stem of the river above Morgan Falls and four sites in tributaries that drain into the main stem below Morgan Falls. Three of the five sites surveyed in 2016 had not been surveyed in over 16 years.

Table 5. Estimates of wild-origin Atlantic Salmon smolt abundance (and 95% confidence interval), production per unit area of habitat (smolts/100 m^2) and the smolt-to-adult return rates for the LaHave River.

Smolt Year (t)	Wild Smolt Estimate	95% Confidence Interval	Production Per Unit Area (smolts/100 m^2)	Return Rate (%)	
				1SW (t+1)	2SW (t+2)
1996	20,511	19,886 - 21,086	0.79	1.47	0.23
1997	16,550	16,000 - 17,100	0.63	4.33	0.43
1998	15,600	14,675 - 16,600	0.60	2.04	0.34
1999	10,420	9,760 - 11,060	0.40	4.82	0.86
2000	16,300	15,950 - 16,700	0.63	1.16	0.11
2001	15,700	15,230 - 16,070	0.60	2.70	0.59
2002	11,860	11,510 - 12,210	0.46	1.95	0.45
2003	17,845	8,821 - 26,870	0.68	1.75	0.17
2004	20,613	19,613 - 21,513	0.79	1.13	0.33
2005	5,270	4,670 - 5,920	0.20	7.95	0.54
2006	22,971	20,166 - 26,271	0.88	1.48	0.40
2007	24,430	23,000 - 28,460	0.98	2.33	0.16
2008	14,450	13,500 - 15,500	0.55	1.16	0.30
2009	8,644	7,763 - 9,659	0.33	3.47	0.88
2010	16,215	15,160 - 17,270	0.62	1.81	0.19
2011*	NA	NA	NA	NA	NA
2012*	NA	NA	NA	NA	NA
2013	7,159	5,237 - 10,259	0.27	0.60	0.24
2014	29,175	23,387 - 37,419	1.12	0.55	0.15
2015	6,664	6,011 - 7,413	0.26	0.35	NA
2016	25,849	23,311 - 28,750	0.99	NA	NA

NA = Not Applicable
*Smolt assessments were not conducted on the LaHave River in 2011 and 2012.

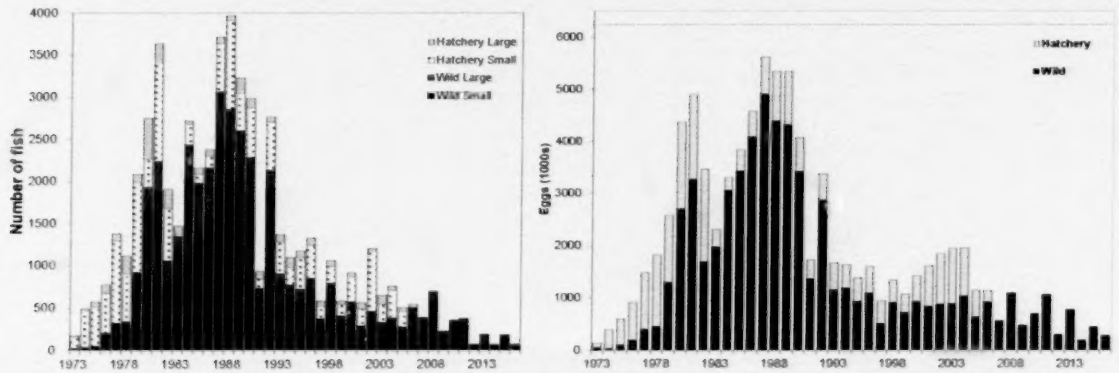

Figure 4. Counts of small and large adult Atlantic Salmon (left panel) and estimated egg deposition (1000's) relative to the conservation egg requirement (right panel) by wild-origin and hatchery-origin Salmon at the Morgan Falls fishway on the LaHave River, NS, from 1973 to 2016. The horizontal dashed line in the right panel indicates the conservation egg requirement above Morgan Falls. Hatchery-origin smolts were no longer introduced after 2005.

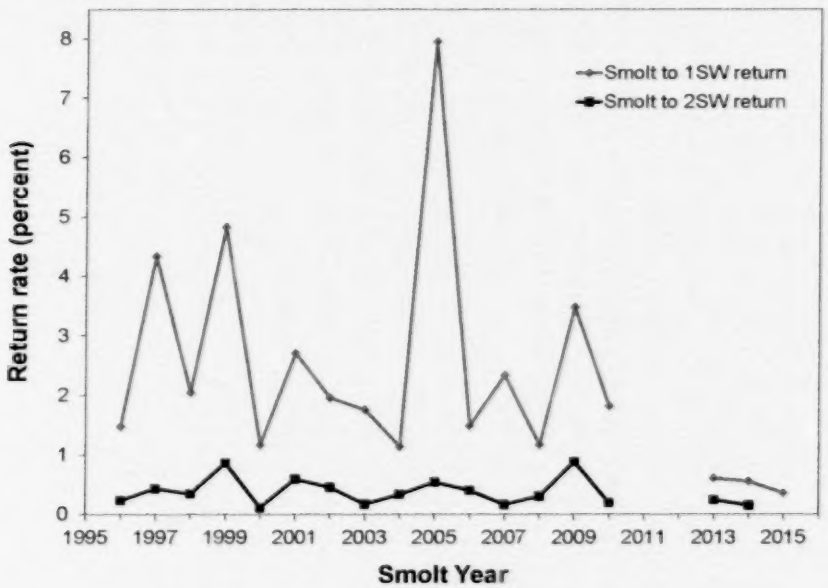

Figure 5. Estimated smolt-to-adult return rates for maiden one-sea-winter (1SW) and two-sea-winter (2SW) Salmon on the LaHave River (above Morgan Falls).

Outer Bay of Fundy (Outer Portion of SFA 23)

Atlantic Salmon assessment activities led by DFO in the OBoF region are currently focused on two river systems: Saint John River (upriver of Mactaquac Dam, which includes the Tobique tributary) and Nashwaak River (tributary of Saint John River downriver of Mactaquac Dam). The Atlantic Salmon Federation monitors adult and juvenile Salmon abundance on the Magaguadavic River. A detailed assessment updating status to 2012 for the OBoF population was completed for the Recovery Potential Assessment of this DU (Jones et al. 2014).

All commercial fisheries for Atlantic Salmon in SFA 23 have been closed since 1984. Low abundance of Salmon has resulted in no FSC allocations and no recreational fisheries since 1998. In 2016, all rivers within SFA 23 remained closed to Salmon fishing all year.

The Mactaquac Biodiversity Facility (MBF) was constructed to numerically offset the effects of hydroelectric development on Salmon in the Saint John River, primarily by producing smolts from sea-run broodstock captured at fish collection facilities at Mactaquac Dam. Based on an agreement within the 'Saint John River Management Advisory Committee' in 2004, the program at the MBF was modified to focus on conserving and restoring a declining resource utilizing captive-reared adults, originally collected from the wild as juveniles, for both broodstock and adult releases for natural spawning upriver of Mactaquac Dam (Jones et al. 2004). About 90 broodstock matings per year are still carried out at MBF for the production of smolts for release downriver of Mactaquac Dam and fall parr for release in the Tobique River.

Egg depositions from spawners in 2016 were estimated to be less than 8% of the conservation egg requirements for each of the three index rivers (Table 6). Assuming the captive reared adults spawn successfully, captive-reared spawners released upriver of Mactaquac Dam in 2016 potentially increased the estimated egg depositions to 21% of the requirement on that section of the Saint John River. In 2016, fry and total parr (age one and older) densities (Table 6) on the Tobique, Nashwaak and Magaguadavic rivers were also low (<3 fish/100 m^2) and remain well below Elson's norm values. The pre-smolt (Tobique) and smolt (Nashwaak) abundance estimates in 2016 were both less than 0.2 fish/100 m^2 of productive habitat, which is very low in comparison to the reference value of 3.8 smolts/100 m^2 (Symons 1979). The smolt-to-1SW Salmon return rate in 2016 (5.04%) was slightly above the long-term mean (1998-2015; 4.32) while the smolt-to-2SW Salmon return rate in 2016 (0.60%) was below the long-term mean (1998-2014; 1.10) for the fifth consecutive year (Table 7). A summary of the 2016 assessment results is provided in Tables 6 and 7 and time series showing the status of Salmon populations for Saint John (upriver of Mactaquac Dam) and Nashwaak rivers are provided in Figures 6-9 and a time series showing smolt-to-adult Salmon return rates is provided in Figure 10.

Table 6. Atlantic Salmon assessment information for index rivers in SFA 23 during 2016, including angling seasons, conservation egg requirements, fish collection facilities/fishway/fence counts, estimated returns, percentage of conservation egg requirements attained, captive-reared adult and juvenile releases, and juvenile and smolt assessment results.

	Saint John River (Above Mactaquac Dam)	Nashwaak River (Above Durham Bridge)	Magaguadvic River
Angling Season (2016)	Closed	Closed	Closed
Assessment Information	- Fish Collection Facilities Count - Juvenile Electrofishing Surveys - Pre-smolt Assessment	- Counting Fence (Mark Recapture) - Juvenile Electrofishing Surveys (above and below Counting Fence) - Smolt Assessment (Mark Recapture)	- Fishway Count - Juvenile Electrofishing Surveys
Conservation Egg Requirement (millions of eggs)	32.30	5.35*	1.35
Fishway or Fence Count:			
1SW Salmon**	504	319	2
MSW Salmon**	192	60	0
Marks / Recaptures / Captures	NA	M=354 / R=61 / C=99	NA
Estimated Returns:			
1SW Salmon**	509	398	2
Proportion Hatchery	0.62	NA	0.00
MSW Salmon**	197	75	0
Proportion Hatchery	0.67	0.01	NA
% Conservation Egg Requirement:			
Without Captive-Reared	**4**	**7**	**<1**
Including Captive-Reared	21	NA	NA
Captive-reared Adult Releases	1,444	NA	NA
Juvenile Releases:			
Age-1 Smolt (below Dam)	2,779 (May)	NA	NA
Unfed Fry	NA	NA	NA
Age-0 Parr	279,761 (Sept./Oct.)	NA	NA
Age-1 Parr	NA	NA	NA
Number of Sites Surveyed and Electrofishing Densities (fish/100 m^2):			
Number of Sites	15***	10	12
Age-0 Parr (Fry)	2.9***	2.2	1.0
Total Age-1 and Older Parr	2.3***	1.0	0.0
Wild-origin Pre-smolt or Smolt Estimate (2.5 and 97.5 percentiles)	8,220*** (6,150-11,910)	7,150 (5,575-9,925)	NA
Pre-smolt or Smolt (fish/100 m^2)	0.10***	0.13	NA

NA = Not Applicable

*The conservation egg requirement reported by Marshall et al. (1997) is calculated based on the habitat area above the counting fence (above Durham Bridge) on the Nashwaak River (i.e., 90%).

**One-sea-winter (1SW) Salmon are those which return to spawn following a single winter at sea (also termed Grilse). Multi-sea-winter (MSW) Salmon include those fish which return following two or more winters at sea and repeat spawning Salmon.

***Electrofishing and pre-smolt results are for the Tobique River (index tributary upriver of Mactaquac Dam).

Table 7. Estimates of wild-origin Atlantic Salmon smolt abundance from upriver of Durham Bridge (and 2.5 and 97.5% percentiles), production per unit area of habitat (smolts/100 m^2) and the smolt-to-adult return rates for the Nashwaak River, 1998–2016.

Smolt Year (t)	Wild Smolt Estimate			Production Per Unit Area (smolts/100 m²)	Return Rate (%)	
	Mode	2.5%	97.5%		1SW (t+1)	2SW (t+2)
1998	22,750	17,900	32,850	0.43	2.91	0.67
1999	28,500	25,300	33,200	0.54	1.79	0.84
2000	15,800	13,400	19,700	0.30	1.53	0.28
2001	11,000	8,100	17,400	0.21	3.11	0.90
2002	15,000	12,300	19,000	0.28	1.91	1.26
2003	9,000	6,800	13,200	0.17	6.38	1.58
2004	13,600	10,060	20,800	0.26	5.13	1.28
2005	5,200	3,200	12,600	0.10	12.73	1.52
2006	25,400	21,950	30,100	0.48	1.81	0.62
2007	21,550	16,675	30,175	0.41	5.63	1.26
2008	7,300	5,500	11,200	0.14	3.86	2.05
2009	15,900	12,150	22,850	0.30	12.41	3.31
2010	12,500	9,940	16,740	0.24	7.86	0.35
2011	8,750	7,130	11,300	0.17	0.33	0.98
2012	11,060	8,030	17,745	0.21	1.63	0.29
2013	10,120	8,840	11,800	0.19	1.61	0.45
2014	11,100	8,150	17,200	0.21	2.86	0.60
2015	7,900	6,520	9,980	0.15	5.04	NA
2016	7,150	5,575	9,925	0.13	NA	NA

NA = Not Applicable

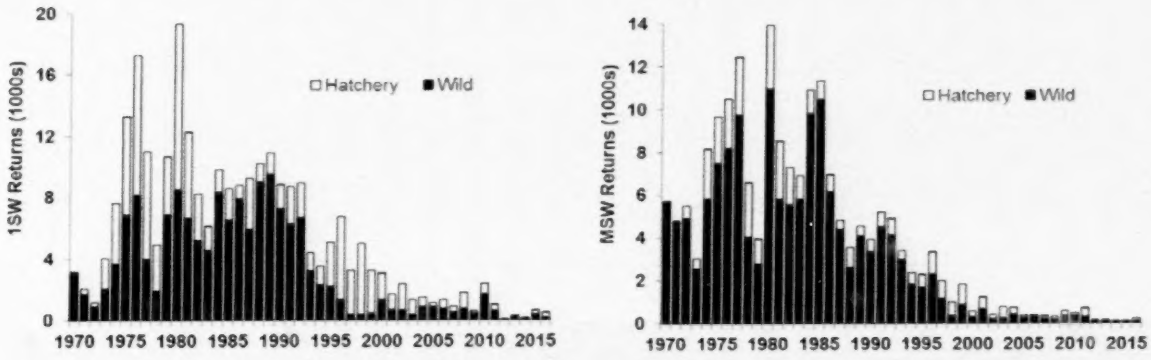

Figure 6. Estimated wild and hatchery-origin one-sea-winter (1SW) and multi-sea-winter (MSW) returns destined for upriver of Mactaquac Dam, Saint John River, 1970-2016.

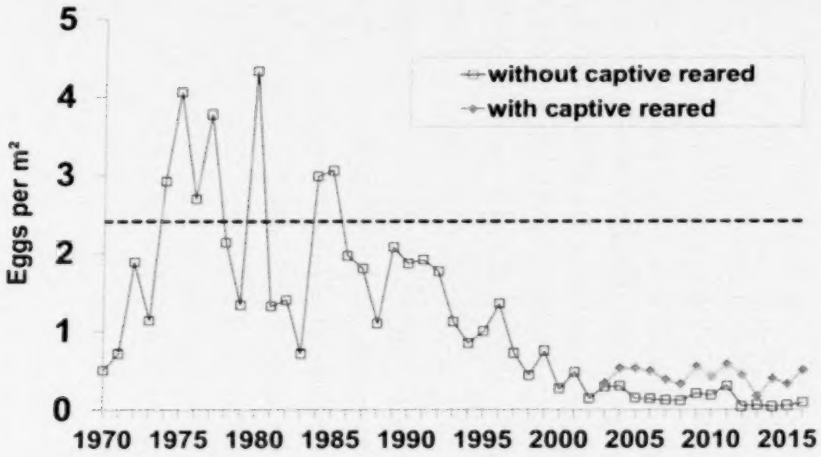

Figure 7. Estimated egg deposition per m^2 (wild and hatchery combined, and captive-reared) upriver of Mactaquac Dam, Saint John River, 1970-2016. The horizontal dashed line is the conservation egg requirement (2.4 eggs per m^2).

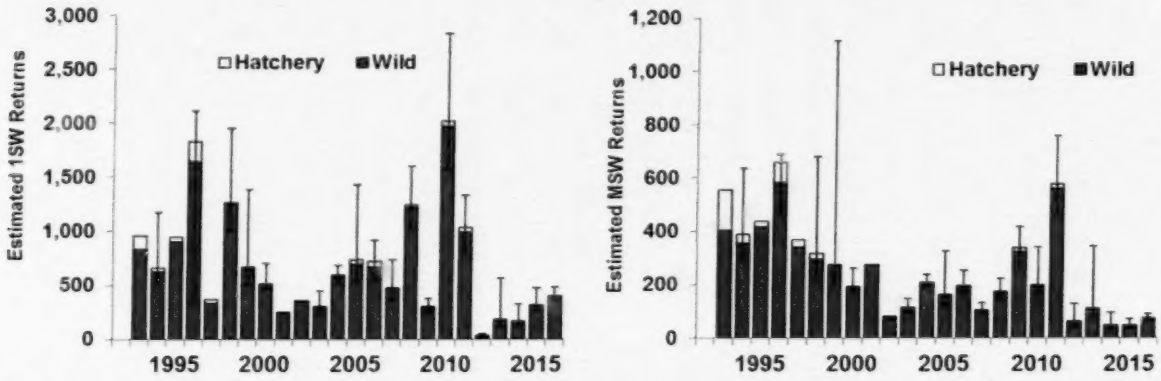

Figure 8. Estimated wild and hatchery-origin one-sea-winter (1SW) and multi-sea-winter (MSW) Atlantic Salmon returns (and 2.5 and 97.5 percentiles) to the Nashwaak River, 1993-2016. No hatchery-origin releases since 2010.

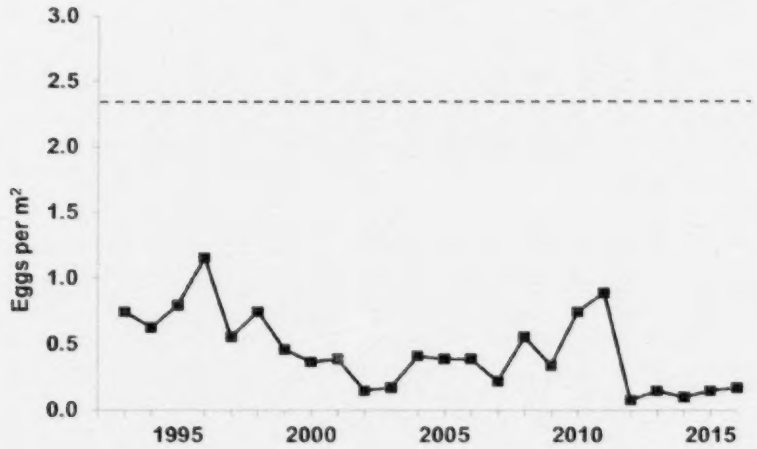

Figure 9. Estimated egg deposition per m^2 upriver of the counting fence operated just below Durham Bridge, Nashwaak River, 1993-2016. The horizontal dashed line is the conservation egg requirement (2.4 eggs per m^2).

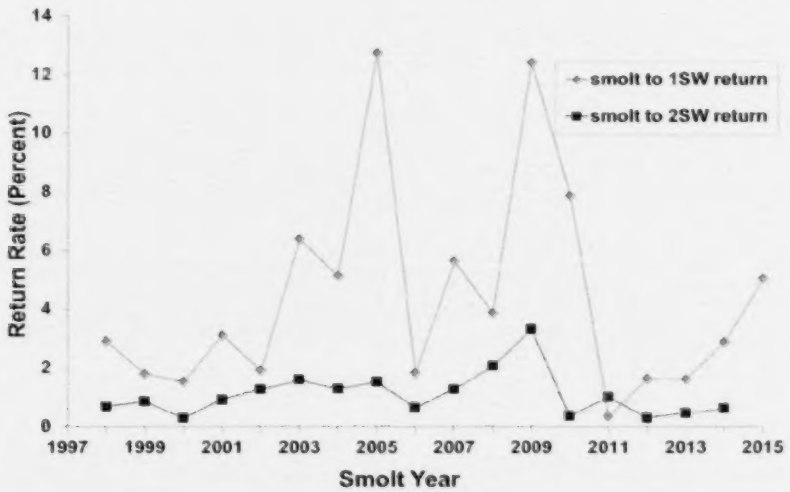

Figure 10. Estimated smolt-to-adult return rates for maiden one-sea-winter (1SW) and two-sea-winter (2SW) Salmon on the Nashwaak River (above Durham Bridge).

Sources of Uncertainty

There are on-going informal reports of illegal fishing activities (e.g., fishing in closed areas and poaching), but the combined contribution of these activities to the depressed status of populations is not known.

The number of small and large Salmon caught and released, fishing effort, and catch and release mortality within SFA 19 are estimated from license stub returns from the recreational Salmon fishery. Catch and effort values are adjusted for non-returned stubs using a relationship based on the reported catch as a function of the number of reminder letters sent to licensed

anglers. For recreational catch data, under- or over-reporting of numbers of Salmon caught and fishing effort would impact assessment results based on these data. Estimates for 2016 are considered to be preliminary at the time of this status update since license sale information and license stubs are still being returned. In recent years, catch and effort estimates prior to sending reminder letters to anglers have generally been systematically higher than catch and effort estimates after reminder letters have been sent. In an attempt to reduce this bias in years where reminder letters were not sent to anglers (i.e., 2004, 2008-2010, and 2016), individual river mean scaling factors (i.e., estimate after reminder letter information divided by reported value prior to reminder letter information) for small Salmon, large Salmon and effort have been applied to reported values to estimate catch and effort. These observations coupled with the observation that the North River Salmon abundance estimated from the recreational catch data has consistently exceeded the abundance estimated from dive counts during the 2002-2014 time period (Figure 2) indicate that the recreational catch data for North River should be interpreted with caution and field surveys should be conducted to assess whether the current use of recreational catch data is appropriate for future assessments.

A pool count of Salmon returns was conducted on North River during September 1st and 2nd where 34 large and 10 small Salmon were counted, and a dive count was conducted on October 26th where 35 large and 6 small Salmon were counted. The visibility during both of these counts was considered to be unsuitable for population assessment purposes. During the North River dive count on October 6th the water levels were low and the visibility was considered to be well above average despite only seeing 13 of the 26 Salmon marked on October 4th and 5th. Therefore, the maximum observation rate (0.62) for historical dive counts was used to estimate escapement rather than the mean (0.48).

There was uncertainty distinguishing some of the parr from smolts captured in the rotary screw trap on Middle River based solely on morphological characteristics. Therefore, for the purposes of estimating smolt abundance, juvenile Salmon were assumed to be smolts if they were greater than 10.0 cm in fork length and did not clearly resemble parr. All scale samples aged from fish over this threshold were estimated to be Age 2 or older, although there were a few juveniles >10 cm in length that seemed to be more morphologically similar to parr than smolts. Further work to resolve this uncertainty is underway. The smolt wheel was monitored daily from May 6 to June 13, 2016; however, challenges in operation (largely due to low flow conditions) prevented sampling on seven days (May 27-30th and June 3, 4, 6th). The impact of these breaks in monitoring on the estimate is unknown; these dates occurred after the peak of the smolt run (May 18-22nd), and may have influenced the estimate due to the inability to recapture smolts that were marked during the peak of the run along with unmarked smolts that were migrating during these lower flow periods.

Juvenile density (number of fish per 100 m^2 of habitat area) was calculated using the catch-per-unit-effort (CPUE) method described by Chaput et al. (2005) for single-pass electrofishing at open sites (i.e. where no barrier nets are used). By adding 1 to the observed CPUE, density was estimated from a log-transformed general linear model. One limitation of this modeling approach is that sites in which no individuals of a particular age are captured still have a small predicted population density (e.g., 4.1 fish/100 m^2). This method causes densities including sites with no fry or parr catch to be biased high. ECB rivers where no fry were captured include Benacadie River, River Tillard, Neil Brook, and Warren Brook. Age 1 and older parr were captured in all rivers with the exception of Neil and Warren brooks where no fry or parr were captured.

Although some populations in ECB have been closer to their conservation egg requirements than those in the OBoF and SU regions, substantial declines are evident in other ECB populations (e.g., Grand River and Clyburn Brook). There is uncertainty in the status of

populations in non-index rivers, which has been inferred from recreational catch data and limited electrofishing data (Levy and Gibson 2014).

Further details on the uncertainty associated with these assessment methods can be found in DFO (2013).

Conclusions

All Atlantic Salmon index populations within DFO's Maritimes Region were assessed to be below conservation egg requirements in 2016. SU and OBoF Atlantic Salmon populations remain critically low. Adult Salmon returns to the LaHave River (SU), the Saint John River upriver of Mactaquac Dam, and the Nashwaak River (OBoF) remain among the lowest returns on record with estimated egg depositions ranging between 4-7% of conservation egg requirements in 2016. Moreover, recent smolt to adult return rates (a proxy for marine survival) for 1SW Salmon on the LaHave River were estimated to be the lowest on record with values less than 1% for the 2013, 2014, and 2015 smolt cohorts. Smolt to adult return rates on the Nashwaak River were also low and below the long-term mean for 2SW returns (for the fifth consecutive year) and just slightly above the long term mean for 1SW returns. Some populations in the ECB region have been closer to conservation egg requirements than those in the OBoF and SU regions, although egg depositions for ECB index populations remained below conservation egg requirements with values ranging between 30-79% of these requirements in 2016.

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Date: March 22, 2027

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Appendix

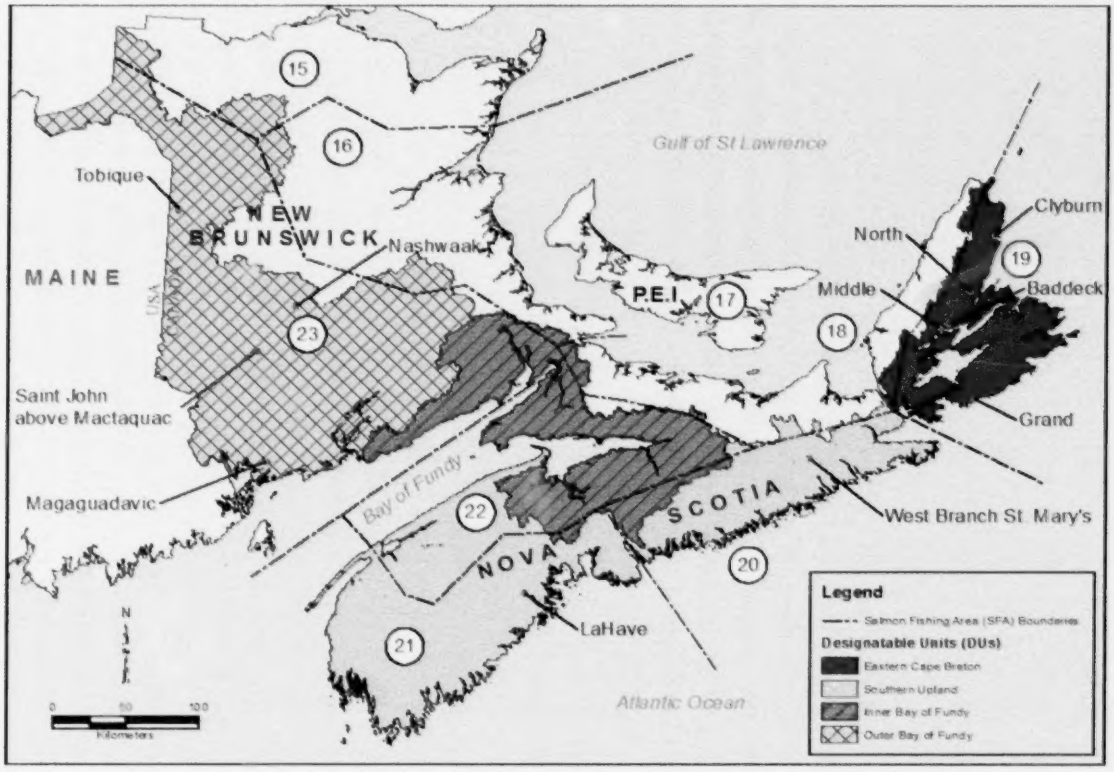

Figure A1. Map showing the locations of Atlantic Salmon rivers where monitoring predominately occurred, Salmon Fishing Areas (SFAs), and Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Designatable Units (DUs) mentioned in this update. SFA numbers are labeled inside the white circles. Data Source for DUs derived from NS Secondary Watershed Layer (NS Dept. of Environment) and NB Watershed Level 1 Layer (NB Dept. of Natural Resources). Note: Location of all rivers electrofished in eastern Cape Breton are not shown.

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ISSN 1919-3769
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Correct Citation for this Publication:

DFO. 2017. Stock Status Update of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2017/020.

Aussi disponible en français :

MPO. 2017. Mise à jour de l'état du stock des populations de saumon de l'Atlantique des ZPS 19 à 21 et 23. Secr. can. de consult. sci. du MPO, Rép. des Sci. 2017/020.